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THE FORESTS OF WYOMING

THE WOOD RESOURCES OF WYOMING AND PROGRAMS FOR THEIR MAXIMUM UTILIZATION

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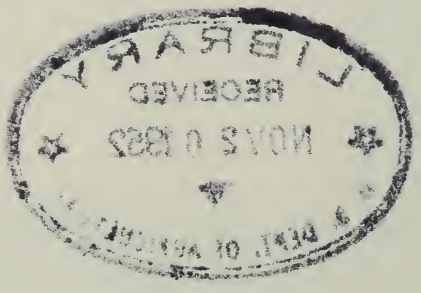
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FOREWORD

On January 3 of this year I forwarded to Mr. J. Elmer Brock, chairman of the Wyoming Resources Board, for the use of his organization a report outlining the status of Wyoming timber resources and setting forth some of the possibilities for expanding the use of those resources. The interest in this report, which was prepared by the United States Forest Service at my request, has been so widespread, not only in Wyoming but in other States having similar problems of forest resource use, that I have asked to have certain sections of the original report expanded and additional statistical data supplied, with a view to the publication of the study as a Senate document.

At the time the preliminary report on Wyoming forests was released I pointed out that less than half of the State's timber resources are now being used. It is estimated, for example, that the annual saw timber harvest could be increased from the present annual average cut of 50 million board feet to over 130 million board feet and the volume of all other wood products doubled.

Nearly one-seventh of the total area of Wyoming—namely, 62,404,000 acres—is in forests and 3 million acres can be classified as forest land suitable for commercial use—producing or capable of producing usable wood crops. In seeking to extend the needed research on ways and means of developing new uses of the kinds of timber grown in Wyoming, I have requested the Forest Service, through its Forest Products Laboratory at Madison, Wis., to arrange for a number of special tests of Wyoming timber. The report describes those laboratory tests which are under way at this time and summarizes the findings of earlier studies such as the highly successful work done on the treatment of Englemann's spruce which permitted the region to retain the market for its railroad ties.

One of the most important studies presently scheduled for Wyoming woods by the Forest Products Laboratory is a specific gravity survey to determine the average weight of wood, both on a green and dry basis, per unit volume, and to determine the variations which may exist within a given species. Such a survey of wood from representative sites in Wyoming will indicate the relative value of wood grown there in comparison with that from other sources. For example, it is common practice to sell pulpwood by the stacked cord and to manufacture it into pulp that is sold by the ton. Wood of high specific gravity—that is, wood which is relatively dense—will therefore yield more tons of pulp per cord than a wood of low specific gravity. Modern marketing methods, consequently, require the kind of detailed information which can be developed only by such specific gravity tests.

In addition to reviewing present and projected research carried out in the laboratory, the report describes field research under way in forest and watershed management and the application of the findings

to the successful use and maintenance of Wyoming forests. A detailed analysis is included of further research or extension of improved forest practices which are needed if the State's forest resources are to be fully developed.

The study was prepared from the best available sources by technicians in the United States Forest Service through the cooperation of the Chief of the Forest Service, Mr. L. F. Watts. Special appreciation for major portions of the materials submitted is due Bert R. Lexen, Assistant Chief, Division of Forest Management Research, and L. S. Gross, staff assistant, Division of Timber Management, who assembled the preliminary study, and R. M. Wirka, assistant chief, Division of Forest Products, and Dr. J. Alfred Hall, director, Forest Products Laboratory, who assisted with the present report. John W. Lehman, clerk of the Joint Committee on the Economic Report, assisted throughout in the organization and preparation of the materials for publication.

JOSEPH C. O'MAHONEY.

THE FORESTS OF WYOMING

INTRODUCTION

The total land area of Wyoming is 62,404,000 acres. About one-seventh of this area, or 8,878,000 acres, is in forest. The rest is classified as follows:[1]

	Acres
Cropland in ranches	3, 513, 000
Pasture and range:	
In ranches	23, 746, 000
Not in ranches	25, 196, 000
Other (roads, urban, waste, etc.)	1, 071, 000

Of the 8,878,000 acres of forest land, 3,012,000 acres are considered to have commercial possibilities which when properly developed and managed will yield on a continuous basis substantial crops of saw timber and other forest products.[2] The remainder of the forest lands are either inaccessible or of low productivity (3,997,000 acres), or have been withdrawn for such public purposes as parks and recreation areas (1,866,000 acres).

Most of the forest land in Wyoming is publicly owned and the major part of the commercial forest is managed by the Forest Service, as can be seen from the following tabulation of the forest land pattern by ownership and volumes: [3]

Ownership	Area (in thousands of acres)		Volume, thousand feet board measure (commercial only)
	Non-commercial	Commercial	
Federal Government:			
National forests	2, 308	2, 187	8, 886, 000
Indian reservations	207	146	759, 000
National parks and monuments	1, 637		
Grazing service	607	79	395, 000
Other Federal	278	122	156, 000
Total	5, 037	2, 534	10, 196, 000
State of Wyoming	91	72	145, 000
County and municipal	1	2	8, 000
Private:			
Ranch woodland	347	248	389, 000
Industrial and other	389	156	314, 000
Total private	736	404	703, 000
Grand total, all ownerships	5, 865	3, 012	11, 052, 000

[1] In 32 of the 48 States, estimates of timber volume, area, ownership, current growth, and other related facts pertaining to the forest resource have been made by the National Survey of Forest Resources. No systematic survey such as made by the National Survey has yet been made for Wyoming. The data presented in this report have been obtained from various sources, and are believed to be the best information available at present.

[2] Land which is producing, or physically capable of producing, usable crops of wood (usually saw timber), economically available now or prospectively, and not withdrawn from timber utilization.

[3] A large part of this forest is under multiple use, where timber production under sustained yield is coordinated with other uses of the forest, such as recreation, grazing by domestic livestock, production of wild life, and the maintenance of satisfactory watershed conditions.

The chief species of timber in Wyoming's forests are lodgepole pine and Engelmann spruce. Saw-timber volumes of lodgepole pine, Engelmann spruce, and other species, and the volumes of the smaller, pole-sized trees which are available for pulpwood at present but could also be used for lumber sometime in the future are shown below.

Commercial saw-timber stands by species

Species	*Volume, thousand board feet measure*
Softwoods:	
Lodgepole pine	5, 123, 000
Engelmann spruce	2, 629, 000
Ponderosa pine	1, 199, 000
Douglas fir	1, 161, 000
True firs	339, 000
Others	100, 000
Total softwoods	10, 551, 000
Hardwoods	501, 000
Grand total, all species	11, 052, 000

Pole timber stands available for pulpwood

[In thousand cords]

Species	*Volume, thousand board feet measure*
In saw-timer areas:	
Softwoods	9, 528
Hardwoods	69
Total in saw-timber areas	9, 597
In pole timber areas:	
Softwoods	12, 341
Hardwoods	1, 062
Total in pole timber areas	13, 403
In other forest areas:	
Softwoods	697
Hardwoods	201
Total in other forest areas	898
Grand total in all timber areas	23, 898

The following report attempts to set forth the significance of present and potential productive capacity of the forest resources of Wyoming, to review existing and proposed programs directed toward the greatest utilization of these resources, and to point the way to additional work which is needed if such an objective is to be fully achieved.

PRODUCTIVE CAPACITY OF WYOMING FORESTS

Current and past production

Full use of Wyoming's timber resource is yet to be realized. Over the past 20 years the cut of lumber and sawn ties in Wyoming has been over a billion board feet, an average of approximately 50 million board feet annually. The greatest reported cut was 80,815,000 board feet in 1947. During the period 1948–50 the cut varied from 64 to 68 million feet of lumber and ties. This is considerably below the estimated sustained yield for the forests of Wyoming.

Production under present forest practices

Estimates of the allowable cut indicate that the annual saw-timber harvest could be safely increased to 116 million board feet annually on the national forest and another 14 million board feet could be obtained from State, county, and private lands or a total of 130 million board feet for all forest lands within the State. In addition, there is an opportunity to double the volume of wood products used annually by better utilization. It is estimated that on the typical Wyoming cutting area 50–60 percent of the timber volume is left in the woods. This is waste in the form of small-size trees and logs, broken and partially rotted sections of trees, slabs and sawdust. Utilization of timber has improved in recent years because of the great demand for wood products, but much still needs to be done in order to make the most of the State's timber resource.

Production under intensive management

In several of the intensively used forest regions in the United States, forest research has developed cutting methods that have stepped up yields, improved timber quality, and reduced losses from insects and disease. Similar progress is possible in Wyoming but at present the technical know-how is lacking. Forest research could not, of course, be expected to increase the yield of Wyoming timber to a point where it would equal the yield of forests where climatic conditions are more favorable. It is possible, however, to improve current yields considerably despite the severe climate of Wyoming.

In view of what has been accomplished elsewhere by research and the application of research findings it appears safe to assume that the sustained timber growth for the State could be increased from 130 million board feet to roughly 200 million board feet annually.

CURRENT USES MADE OF WYOMING TIMBER

Cross ties

Wyoming timber is suitable for many uses. For over a half-century lodgepole pine and Engelmann spruce have been important sources of railroad cross ties for the Rocky Mountain West. Production records show that as many as 3 million lodgepole pine ties have been produced annually and while exact figures are not available for Wyoming it is known that the State's contribution to the total output has been considerable.

The continued use of lodgepole pine for cross ties is ample evidence that this species meets the needs for this purpose. Moreover, fair accessibility to a main-line railroad and the ease with which lodgepole pine takes preservative treatment is bound to insure a permanent demand for this wood.

Power and telephone poles

Because of its form, combined with its ability to readily take preservative treatment, lodgepole pine has enjoyed considerable demand for telephone and power poles. Lower production costs in the South, however, have made the southern pines a strong competitor for this market. At present the shipment of Wyoming power and telephone poles is limited largely to those areas where the differential in freight rates is in its favor.

Production of poles in Wyoming for 1948, 1949, and 1950 was 60,000, 40,000, and 56,000, respectively. Many more poles could, of course, have been produced were it not for the limited market in which Wyoming poles must be sold.

Lumber

Both lodgepole pine and Engelmann spruce make good common lumber for construction use but are not particularly suitable for interior finish, window framing, or doors. Excellent knotty pine paneling can be made, however, from lodgepole pine. Small sound knots and the dimpled appearance of tangential surfaces make this wood well adapted for interior panel finishing.

Lodgepole pine can be manufactured into siding and flooring but is inferior to many other species used for these purposes. It can be satisfactorily used for flooring when it is covered with other material such as linoleum or rugs.

Mine timbers and posts

Lodgepole pine and, to a lesser extent, Engelmann spruce is ideally suited for round stulls, lagging poles, and fence posts. Periodically there is a strong market for these items, but unfortunately it is not a very firm market. Here, as with power and telephone poles, freight rates rule against the possibility of a large fence post industry developing in Wyoming.

IMPORTANT FORESEEABLE FUTURE USES

Pulpwood

As pulpwood, lodgepole pine compares favorably with jack pine, a highly valued pulpwood species in the Lake States. The wood reduces readily by the sulfite process to produce an easily bleached, strong pulp of excellent color. This pulp is suitable for the manufacture of papers such as newsprint, wrapping, book, and high-grade printing. The wood can be used for ground-wood pulp but requires in the neighborhood of 20 percent more power for grinding than Engelmann spruce. When it is pulped by the sulfate process it makes a very strong dark-colored pulp suitable for making high-grade kraft papers and fiberboard.

Engelmann spruce makes a high quality pulp which is equal to that made from the much sought after eastern spruce. Spruce pulpwood has brought top prices since the beginning of the paper industry in this country, and even during World War II ceiling prices were greater for spruce than any other species. This price differential in favor of spruce is largely the reflection of the quality of paper pulp that can be made from it and the ease with which it can be pulped. Engelmann spruce is readily reduced by either sulfite or sulfate process. The sulfite pulp has an excellent color and bleaches easily. It is suitable for any type of paper and is especially valuable in the manufacture of high-grade printing and bond paper. Engelmann spruce also reduces easily by the mechanical process and requires a minimum of power in the grinding operation.

For several years Lake States pulp mills have been using considerable quantities of lodgepole pine pulpwood from eastern Montana and Engelmann spruce pulpwood from Colorado. In 1950 the total was 64,000 cords, and in 1951 it was 100,000 cords. Long-distance ship-

ments of so bulky a product as pulpwood become economic only during periods of short supply and relatively high prices. It may be practicable to ship some Wyoming pulpwood to distant mills, but that market probably could not be depended upon as a permanent outlet.

An alternative would be the development of pulping facilities in Wyoming. Preliminary investigation has shown that an annual cut of some 60,000 cords (largely lodgepole pine and Engelmann spruce) could be sustained for a pulp mill located on the upper Green River in the southwestern part of the State. This cut is sufficient for a small pulp mill but before it can be established research will need to determine whether serious problems of water supply and effluent disposal can be satisfactorily solved.

Fabricated building materials

There are also possibilities for the manufacture of coarse fiber pulps for use in roofing felt, insulation board, and hardboard by essentially dry processes. Very little water is required for such procedures and since there is no effluent the problem of waste disposal is avoided. Dry processes for the manufacture of hardboard and certain kinds of insulation materials are being developed on a commercial scale. The economy of such procedures, particularly for the manufacture of hardboard, seems to be especially attractive. Generally speaking, the wood-quality requirements for these products would be much lower than those for the higher-quality pulps mentioned earlier. Various kinds of wood waste or any lower-quality wood type should be suitable for these products.

A number of hardboard processes, using both wet and dry methods, are available for licensing. Production of these materials has been expanding rapidly in plants considerably smaller than those required for the manufacture of pulp. The Pacific Northwest is especially active in this field and the species found in Wyoming, particularly lodgepole pine, are suitable for these products.

STATUS OF RESEARCH

Forest products research

The Forest Service's Forest Products Laboratory keeps closely in touch with forest products utilization problems throughout the United States. In Wyoming, forest products problems are handled by the Forest Service's Rocky Mountain Forest and Range Experiment Station at Fort Collins, Colo., which is concerned with the efficient utilization of all types of timber in the region. The forest products research needs of the Rocky Mountain region, including Wyoming, are reported regularly to the laboratory staff through this station.

Use and milling studies in the region

Several investigations and problem analyses have been made in the Wyoming region by technicians and specialists from the Forest Products Laboratory. These have included a study of the problems connected with the utilization of lodgepole pine and Engelmann spruce (1945), and an analysis of sawmilling and logging problems (1950).

As recently as August 1951, a group of owners and operators attended a United States Forest Service sawmill demonstration at La Barge, Wyo., at which methods of producing more accurately

sawed and sized lumber at lower cost by methods that required less power and fewer workmen were set forth by Forest Products Laboratory specialists. In other visits to Wyoming mills, these specialists were able to show operators how to improve production and lower costs by adopting new procedures and making better use of equipment.

Pulp and paper from Wyoming woods

The Laboratory's pulping experiments on Rocky Mountain woods have firmly established the technical basis for a pulp industry in this region and have also opened markets in Lake States pulp mills for Engelmann spruce and lodgepole pine. These species and the true firs produced pulp of excellent quality. Beetle-killed Engelmann spruce, as well as the green wood, produced high-quality pulps suitable for newsprint and many other papers. Although the wood of Engelmann spruce is rather light in weight, the yield of pulp per cord from this species and lodgepole pine is high because of the generally high quality of the wood, its thin bark, and correspondingly high volume of wood per cord. Alpine fir is soon to be tested.

Extensive investigations have also been conducted at the laboratory on the pulping of aspen and other hardwoods. Although these species produce short-fibered, relatively low-strength pulps, methods have been developed for their use in many grades of paper. This use has expanded rapidly in recent years. For example, aspen constitutes about 25 percent of the pulpwood used at present in Wisconsin. The findings in this investigation apply equally well to the aspen available in the Rocky Mountain region.

The Forest Products Laboratory has also given some consideration to the possibilities of developing various degrees of conversion of the desirable pulping species before shipment. The need for such information arises from the fact that because of the water requirements and the problems of effluent disposal, the manufacture of pulp or paper by a chemical process may not always be possible in localities where good pulpwood is available. In such instances there are other possibilities that may be considered. The shipment of pulpwood chips, for example, has expanded considerably during recent years, particularly on the Pacific coast. Although this practice may not always be feasible for long-distance shipments, it may be practical for shorter hauls. The feasibility of these procedures would, of course, be determined by freight rates available on such material and the cost of handling.

Another possibility for further conversion of Wyoming pulpwood lies in the manufacture of ground-wood pulp. Ground-wood pulp is made by a simple operation of grinding wood blocks on a large grindstone. The pulp can be manufactured quite economically in small units without using large quantities of water and usually without creating difficult pollution problems. It is used principally in newsprint and other printing papers and paperboard. There are also possibilities for modifications of the ground-wood process to make higher qualities of pulp for special uses but the development of such uses will require additional investigations by interested public and private agencies.

Wood preservation

Lodgepole pine, Englemann spruce, and ponderosa pine of Wyoming (all good cross-tie species) and vast mileage within the State of transcontinental railroads and rural power lines have provided the

basis for a number of investigations by the Forest Products Laboratory of the preservative treatment and use of Wyoming woods for poles, posts, and railroad ties.

As a result of on-the-spot studies by the laboratory the serious cross breakage of ponderosa pine railroad ties that once threatened the continued use of ties of this species has been diagnosed and controlled. At one time a costly percentage of locally grown ponderosa ties in Wyoming tracks of the Burlington Railroad were failing by cross breakage within 2 to 5 years after installation. Examination by a Forest Products Laboratory technician disclosed that the ties in question showed characteristic amounts of compression wood—an abnormal type of growth frequently found on the inclined side of cone-bearing trees. Compression wood, unlike normal wood, shrinks and swells considerably lengthwise. The cross breaks caused by the shrinkage of compression wood on drying out were controlled by substituting a 50–50 mixture of creosote and petroleum oil for the zinc chloride (a water-borne preservative) then in use as a decay preventive. Inspection after 10 years of wartime service showed no indications of breakage due to compression wood. Cross breaks that might result from compression wood common in such other Wyoming woods as lodgepole pine and Englemann spruce can be controlled in the same manner.

Methods devised at the Forest Products Laboratory for treating Engelmann spruce, one of Wyoming's principal tree species, literally saved one important market for that species by one series of treating demonstrations at Laramie. Because of earlier troubles in the treating process for this wood, the Union Pacific Railroad had threatened to discontinue the use of Engelmann spruce ties entirely. The success of the Laramie treating demonstrations, as well as others at Sheridan and Riverton, led to the continued use of many thousands of Engelmann spruce ties.

Lodgepole pine, another common Wyoming species, is being tested by the laboratory in cooperation with the Rural Electrification Administration for use after treatment with preservatives, for electric line poles near Worland, Wheatland, Cody, and Saratoga. The purpose of the test is to find the pole that will give the maximum service at a minimum cost.

The sapwood of all species of wood decays quickly without preservative treatment when used as fence posts, mine timbers, and similar products. Simple nonpressure treatments are being developed for lodgepole pine, Rocky Mountain type Douglas fir, and ponderosa pine to improve the service life.

Cooperative studies have also been carried out with a pole-treating company in the effort to improve the methods by which lodgepole pine poles are seasoned for preservative treatment against decay. The core of the problem has to do with the moisture content of poles at time of treatment. Poles cannot be economically and satisfactorily treated if the moisture content is too high; the problem was how quickly to determine when poles in the seasoning pile are ready for treatment.

The study showed that in a pole pile in which a few bottom courses were relatively open and in which alternate courses ran 8 and 40 poles to the course, an electric moisture meter could be used to get a satisfactory moisture determination for the entire pile by meter read-

ings on accessible poles. An extra long electrode (1¼ inches) was used on the moisture meter and readings were taken at the pole's critical future ground line in each case. Blue stain and mold were controlled by the piling method used.

A considerable amount of experimental work, some of it on Wyoming woods, has been done on a new method of imparting a relatively permanent preservative treatment to wood. It is called the double-diffusion treatment and consists of steeping wood first in a solution of a suitable chemical that diffuses into the wood, and then steeping in a solution of another chemical which upon diffusion into the wood forms a precipitate that is high in toxicity to decay organisms but low in solubility so that its loss by leaching is negligible. Extremely encouraging results have been obtained by field tests started 11 years ago.

Because of the simplicity of the method and the cheapness of the equipment (used oil drums), the method appears to be especially promising for the treatment of fence posts on farms or ranches, especially in areas distant from commercial wood-treating plants. Of the species native to Wyoming, experiments have been made on lodgepole pine and aspen. It is planned next to study the applicability of the process to Engelmann spruce fence posts and telephone poles.

Strength properties of Wyoming woods

Basic strength data have been obtained for 175 of the commercially important wood species of the United States, including many of those grown in Wyoming—principally aspen, cottonwood, Douglas fir (Rocky Mountain), and alpine fir, Rocky Mountain juniper, limber pine, lodgepole pine, ponderosa pine, Engelmann spruce, and white spruce. Such fundamental test data, obtained from tests of specimens of the clear wood of the species, make it possible to use wood properly whenever its strength is of primary consideration and provides for its most effective utilization.

Basic strength data have been obtained on Douglas fir (Rocky Mountain) including one shipment from Johnson County, Wyo. This species is widely used in the construction field and its properties in the form of beams and columns have been studied; the latter to give more precise information of the effect of knots on strength was completed only recently. Studies have shown its performance as studs, joists, rafters, and sheathing lumber for homes. Within the past few years the effects of a decay organism, *Fomes pini*, on strength and nail-holding properties have been evaluated to provide for utilization of infected trees that up to now have been left in the forest.

Alpine fir is a lower-density and lower-strength species, but it could be used successfully as sheathing or subflooring material and as framing members in house construction if the member size were increased over that used in Douglas fir or ponderosa pine.

Basic strength data have very recently been obtained on Rocky Mountain juniper, also known to the trade as Rocky Mountain red cedar. This species finds use as lumber or in fence posts.

Basic data have been obtained on lodgepole pine, including material from Johnson County, Wyo. The wood is relatively easily treated with a preservative to make it decay resistant and in treated form it is primarily used as poles, mine timbers, and railroad ties. A study has been completed only recently that evaluates the performance of

this wood as a pole species and places it in proper position as compared to other species used for poles. Basic strength data for limber pine indicate somewhat the same density as lodgepole pine and would on this basis be expected to have the same properties and fields of use. It is used as rough construction lumber, mine timbers, railroad ties, and poles.

Ponderosa pine is the most important western pine and is second only to Douglas fir in total stand in the United States. Lumber cut from the larger trees is soft and uniform in texture and finds major use as sash and door lumber, trim, and moldings. Lower-grade lumber is well fitted for boxes and crates and a study is presently under way to determine the acceptable size of knots in material of this species used in the construction of ammunition containers. The flush doors that are finding widespread use today use ponderosa pine edge frames which frequently have a ponderosa pine core. The serviceability of these doors is measured through the use of test methods and performance standards that have been developed at the Laboratory.

Wyoming woods for containers

Forest Products Laboratory data on the strength and related properties of Wyoming woods have been used to open the way to their fullest possible effective use as boxes, crates, and other wood shipping containers. Simple rules, formulas, and nailing schedules for making good wood boxes have been available for some years.

In the design of wood boxes the woods commonly used are classified in four groups based on their strength, nail-holding ability, resistance to splitting, and other properties in such a manner that all the woods in any one group may be used interchangeably so far as thickness of material and size and spacing of nails are concerned. Most of the Wyoming woods fall in group I, while Douglas fir is in group II. This classification, together with the design data, makes available a simple and reliable means for making efficient boxes.

Modified wood

Modified wood (compressed wood and compressed, resin-impregnated wood) has been made at the Forest Products Laboratory from cottonwood, spruce, Douglas fir, and many other species of wood. This material has high strength properties and a high degree of resistance to moisture (and consequently reduced shrinking and swelling) and is used for forming dies, tooling jigs, foundry pattern boards, electrical control equipment, and many other industrial applications. It is notable that woods like cottonwood, having low hardness and few properties of top shelf desirability, can be raised to specialty product quality by the improved-wood techniques. Densified wood is being tested in the Rocky Mountain area for use as mine guides in elevator shafts. Many species of woods grown in Wyoming are suitable for making this superior wood product.

Forest management research

Research in the silviculture and management of lodgepole pine and Engelmann spruce is conducted by the Rocky Mountain Forest and Range Experiment Station on the Fraser Experimental Forest near the town of Fraser, Colo. The timber here is somewhat similar to that found in Wyoming. Results so far obtained indicate that lodge-

pole pine responds best to even-aged silviculture or what might be termed regulated clear-cutting. Certain conditions require a modification of this procedure, but in general the complete removal of a mature crop of trees on areas of limited size is producing the best results.

Because of a limited research program, very little progress has been made in the study of Engelmann spruce. This species presents special problems such as heavy windfall losses following cutting and high logging costs. There is some indication that this species will respond best to some form of block, strip, or group cutting, the cutting operation planned so as to avoid losses from windfall as much as possible. Extensive areas of windfall have been found to be the starting point for insect infestations such as are now present in Colorado, and which have resulted in the loss of over 4 billion board feet of timber.

The yield possibilities of lodgepole pine in Wyoming and Colorado have been studied for partially cut stands. These results, while useful in the future management of stand already harvested by partial cutting systems, are not sufficient to meet the needs of newly recommended cutting methods. As to growth, lodgepole pine cannot compete with the rapid-growing pines in warmer climates. It does, however, regenerate easily—in many instances within the year following cutting. This results in efficient production of wood and avoids the loss of 5 to 10 years of timber growth not uncommon with other species of trees. Also because it characteristically grows in dense stands, studies have shown that considerable volume in addition to the final harvest can be removed as the forest matures. This additional volume is in the form of thinnings or small trees for which there is at present only a small market. This material is, nevertheless, admirably suited for pulpwood and will eventually be used for that purpose.

The yield possibilities of Engelmann spruce have been studied in Colorado but not in Wyoming. Colorado studies have shown that it will produce greater yields than lodgepole pine when grown on sites to which it is well adapted. These are usually moist sites at average elevations. On lower and somewhat drier sites lodgepole pine is a superior producer of wood. It often grows on sites which support spruce only with great difficulty.

Successful planting methods have been developed for both species. They are, however, costly and are resorted to only when natural means of reforestation are impossible such as on fire- or insect-devastated areas. A limited amount of research in direct seeding has been done in Colorado. Indications are that this method of reforestation has greater chances of success in the lodgepole pine type than in most types where it has undergone testing thus far. This again reflects the rugged nature of this aggressive species and its unusual ability to cope with severe and difficult growing conditions.

Watershed management research

This activity deals with the interrelations of plants, soil, and water flow on forest and range lands, and the effects of timber cutting, logging, grazing, and other uses on water yields, flood runoff, erosion, and sedimentation.

The application of such research to Wyoming's watersheds is particularly fitting because this State ranks high as a headwater State,

the birthplace of waters which ultimately find their way into three great river basins: the Columbia, the Colorado, and the Missouri. Therefore its water resources and the lands which produce them assume national significance. An active program of investigation and experimentation—now lacking—is needed in order to develop more effective ways to protect and improve these resources, and to help realize their maximum beneficial services.

A brief glance at Wyoming's part in producing useful stream flow indicates the value and importance of watershed research, especially in those portions of the State which produce the highest water yields. Wyoming as a whole receives some 14 inches of precipitation, only 4.1 inches of which become available for stream flow. The higher mountain regions, however, which are mostly in national forests, receive more than 18 inches precipitation and yield 14.7 inches of stream flow, as contrasted to an average of only 2.2 inches of runoff yielded by the lower-lying portions of Wyoming. The heavy contribution of these national forest areas is high-lighted by the fact that, although they occupy but 15 percent of the area of the State, they produce 54 percent of the water which leaves its boundaries.

The bulk of the water yield from the higher mountain lands comes from the extensive areas that are covered very largely by forests of lodgepole pine, Engelmann spruce, and alpine fir. Since full use of these forests has not been realized, they provide fruitful opportunities for thinning or otherwise managing them so as to increase present stream flow.

Although no such investigations have yet been undertaken in Wyoming, the research in this field by the Rocky Mountain Forest and Range Experiment Station in similar forest areas in Colorado shows what can be accomplished. Here the experimental cutting of timber on small plots—resulting in the creation of numerous small openings in otherwise dense forest—has permitted appreciably more snow to reach the ground and to be shaded there against the heat of the sun. This practice has increased the average yield of water available for stream flow by some 4 inches or 30 percent. On a large scale, for similar conditions, this increase would amount to 215 acre-feet per square mile.

Other watershed investigations by the Forest Service in Colorado that may have a direct bearing on Wyoming's conditions concern the effects of commercial logging on erosion, surface runoff, and accelerated flood flows and sediment discharges. Results thus far indicate that where soils are not too erodible, spring melt too rapid, or summer rains too hard, and where care is exercised in building logging roads and in skidding logs, damages to stream flow are usually held to a minimum.

The results do indicate, however, that even in the high country, where spruce and lodgepole pine predominate, the effects of logging may vary considerably with different soils. For example, limited studies show that sandstone soils appear to erode more readily during the spring snow melt than some of the coarser granitic soils under the same kinds of logging practices.

Generally speaking, the more critical situations occur in these mountain areas in Colorado where ponderosa pine prevails. Here the soils—whether granite or sandstone—erode quite readily under the impact of the hard summer thunderstorms that are not uncommon. Common logging practices have here been observed to cause serious

and extensive disturbances to the slopes and watercourses, aggravating the already critical problem of flash floods and destructive siltation of water supply reservoirs, irrigated farm lands, and valley communities.

Watershed research has found that measures and practices to protect against damage to watershed values—either in the spruce or lodgepole pine or ponderosa pine forests—must be designed not merely for average weather but rather for the more extreme rapid snow melts or hard summer rains that may occur once every 10 to 25 years. The real test of stable watershed relations comes at just such times rather than during average years. For this reason watershed research seeks diligently to determine the relations among soil, cover, and water, and to devise methods of protection, logging, road building, etc., that will stand up successfully when these extreme climatic conditions occur.

STEPS NECESSARY TO OBTAIN FULL USE OF WYOMING TIMBER

Improved transportation

One of the important factors in the orderly harvesting of timber crops are adequate access roads. Studies recently completed show that the existing national forest road system includes 59 miles of satisfactory timber access roads and 85 miles of substandard roads. These latter must be reconstructed to a higher standard before they can be used effectively for heavy hauling. In addition there are 400 miles of satisfactory general purpose roads which are used for harvesting timber. Nine hundred and thirty-four additional miles of general purpose roads tap timbered areas but are of such a low standard of construction that they do not contribute appreciably to the harvesting program and to be really useful for such purpose would require reconstruction to a heavier loading standard. The access road system needed for full development of the timber resources amounts to 704 miles, augmented by some 1,800 miles of usable general purpose roads.

The existing road system in the national forests of Wyoming, now is capable of supporting an annual cut of 50 to 60 million board feet. An annual cut of double this amount could be reached in 5 years if necessary timber access roads could be built. This cutting level could then be maintained permanently with only a nominal road maintenance cost.

Much of the present national forest timber production in Wyoming is from accessible stands where a minimum of secondary construction is needed to get the timber to a usable road. Unless new roads are built into now inaccessible timber areas the present level of production will decline.

The faces of large timbered areas cannot be cut into heavily for a long period of time without serious effect upon sustained yield capacity. It is not good business to continue indefinitely to overcut accessible stands while natural losses in the more remote areas through windfall, insects, and disease go unsalvaged.

Timber access roads are built for permanent use, on good grades. They permit harvesting of the timber crop with modern equipment, such as heavy trucks. A good road system is particularly essential with relatively low-value products where operating margins are limited. Adequate roads reduce transportation costs and thereby facilitate marketing of forest products. The cost of the construction and mainte-

nance of timber access roads is met by the returns from the timber. If a timber sale purchaser is required to build a road, the estimated cost thereof is allowed for in the appraisal of the timber. If the road is built by the Government, the timber is appraised at a higher value, because operating costs will be reduced through the availability of the road.

There are understandable reasons why it is not always possible to depend upon so-called operator-built roads to give satisfactory transportation service for sound management of national forest timber. Spur and temporary roads can almost always be constructed by the operator and with minor exceptions all timber sales are made on this basis. The need for publicly built timber-hauling roads is primarily for the permanent main haul roads.

Obviously road construction by a purchaser cannot be obtained until after a sale of timber has been awarded to him. The amount of timber in the sale must be sufficient to justify the construction project. The primary objective of an operator is to remove the timber from the particular sale under award to him without regard to road location and construction standards that would permit economical removal of timber from subsequent sales in the same working circle.

When the main-line transportation system is in place timber sales can be planned and made in proper order in areas most in need of cutting and where danger of serious loss of timber is imminent.

In addition to management considerations, public construction of main-haul roads makes it possible to sell timber in much smaller quantities. This permits the Forest Service to sell timber to small as well as large operators. Many of the small operators are not equipped to undertake the heavy construction work involved in modern haul roads.

Results of the study previously mentioned indicate that some 340 miles of reconstruction and new construction of main-line roads are needed in Wyoming national forests during the next 5-year period to maintain timber production at its present level. This construction is estimated to cost $2,475,000 at present costs.

To double the present rate of timber cutting and reach a level close to sustained-yield capacity during the same 5-year period will involve additional construction of some 380 miles of road at an estimated cost of $3,000,000.

Improved logging methods

Rough terrain and a short season pose special logging problems for much of Wyoming's timber. Methods now in use are costly and either need to be modified or abandoned for methods that are cheaper and more appropriate for small timber and steep terrain where as little damage as possible to soil and hence watershed conditions is vitally important.

Just what method of logging should be used is a job for equipment research to determine. Logging spruce under similar conditions in Switzerland is being done cheaply and satisfactorily by a system of overhead cables. This method of logging, known as the Wyssen system has been tested in New York State and Canada with a fair amount of success. It should be brought to Wyoming for trial and improvement. It is believed that the Wyssen system or an American adapta-

tion of it holds forth considerable promise in reducing logging costs, in markedly reducing watershed damages, and in making more Wyoming timber accessible.

A program of forest management research

Important as it is to secure complete utilization of Wyoming's timber resources, it is by far more important to use them wisely to assure a continuous flow of wood necessary to keep wood-using industries thriving. It is true that greater quantities of timber can be safely cut from Wyoming's forest than is now being done, but the estimate of the safe cutting limit is shaky indeed, and the cultural methods to be used to maintain this cutting level—or any level, for that matter—are still more so.

Heretofore, when the forests of Wyoming were considered as "timber in storage," it was not so important that the technical details of good forest management be known. Now, however, with an ever-increasing drain placed upon the Nation's dwindling timber resource, it is important that much more be known about timber culture in Wyoming. In the years ahead, Wyoming will be expected to contribute more than ever before in its history to the timber needs of our country.

A small research group working intensely on the forest management problems in Wyoming would do much to insure meeting this goal. Such a group could work effectively in cooperation with the University of Wyoming under the general supervision of the Rocky Mountain Forest and Range Experiment Station located in Fort Collins, Colo., only 67 miles from Laramie. Since the present appropriation for forest management research in this region (Wyoming, Colorado, South Dakota, and Nebraska) is very small, additional funds would be needed to carry out this work.

Included among the problems needing immediate attention are:

(1) Cutting methods that will yield maximum growth in the State's two most important forest types, lodgepole pine and Engelmann spruce. The history of the cultural methods used for lodgepole pine is indicative of the present status of knowledge in lodgepole pine and the Engelmann spruce types. In the early 1900's cutting was largely "chopper's choice." Only trees that would easily make a hewn tie were cut. This as a general rule removed the fast-growing elements from the forest and left considerable amounts of small, slow-growing suppressed trees and some large trees (too large for ties) that were too old to respond appreciably to cutting. With the change from hewn ties to sawn ties, cutting practice was changed to include the removal of all but the small unmerchantable trees. Later, in the 1930's studies in Colorado seemed to indicate that additional growth might be gained by partial cutting, but after 15 years it became apparent that partial cutting led to serious wind throw and as a result the gains made by this system of cutting were often lost.

Present indications are that some form of clear cutting—as in narrow strips or small blocks—that will protect the snow pack from rapid evaporation and avoid large extensive accumulation of logging slash will produce the best results from both the standpoint of forest and watershed management. There are, however, many questions concerning this system of cutting that need solution before its general acceptance.

The status of Engelmann spruce cultural methods is still more uncertain. Too little experimental work and actual trials have been

made in Wyoming to form a basis for any but the sketchiest procedures. One thing is certain, and that is whatever cutting system is finally devised, it must leave the residual forest wind firm or windthrown trees will very likely generate a serious insect epidemic.

(2) Since clear cutting will result in the development of even-aged forests containing many stems per acre, it will be necessary to determine thinning schedules which will produce maximum growth and shorten the time required to produce saw-log material. While such schedules are important for Engelmann spruce they are of special importance in lodgepole pine because of the natural tendency of this species to develop into excessively dense stands. Early thinning of lodgepole pine stands, much like the thinning of truck crops, seems to be worthy of careful attention because it can be done cheaply at that time, and will ultimately develop more wind-firm trees.

(3) Information is needed on methods of reforestation, particularly on direct seeding methods that can be used to reforest areas that have been devastated by former fires and insects. Planting or seeding methods to reinforce existing cut-over areas that have not become fully stocked is also needed.

(4) Wyoming timber now lacks the quality necessary for such important items as window sash, doors, and interior finish. Principles have been worked out at forest experiment stations in other regions that have made it possible to improve quality growth of various coniferous trees. These procedures need to be checked in Wyoming to determine if the coniferous species that grow there will respond to these intensive cultural methods and if it is economic to apply them. Basically, this improvement in quality requires adherence to a pruning and thinning schedule. It is possible that since lodgepole pine is particularly noted for the knotty pine paneling that can be manufactured from it, some modification of these schedules will probably be needed.

(5) Statistics on the growth potential of Wyoming's forests is inadequate for scientific management of its woodlands. Some information is now available, but it pertains to timber stands that have been harvested by some partial cutting system or "chopper's choice." What is needed is a thorough analysis of the yield possibilities of forest reproduced in even-aged stands. Such a study will require the development of special techniques to cope with the tendency of lodgepole pine forests to become overdense and stagnate.

A more effective technical wood-use service

Despite special efforts to keep closely in touch with the forest products research needs in Wyoming and the Rocky Mountain region, there admittedly is a need for improved contact between the forest industries of the region and the Forest Products Laboratory. In general, the present arrangements are unsatisfactory because the Laboratory has not funds available which would permit assigning to the Rocky Mountain Forest Experiment Station on-the-spot personnel trained and experienced in the field of forest products to conduct detailed, practical, and current analyses of local wood-using problems, for assistance in solving these problems, and for bringing to the industries the results of research.[4]

[4] In some other regions this work is carried out by a Forest Utilization Service Unit, consisting usually of two well-trained technicians who can concentrate on bridging the gap between the Forest Products Laboratory and the local forest products industries. Among the many activities of these units are investigations of the properties and uses of little-used local species and action to increase their use, improvement, of regional industrial practices by means of field demonstration, and local studies and analyses aimed at the solution of specific problems.

An adequate fundamental research program

It is well to clarify here the part that fundamental research plays in relation to applied research at the Forest Products Laboratory, to the carrying out of cooperative investigations with industry, and to successful consulting service to the public. The Forest Products Laboratory has, in more than 40 years of operation, conducted little "pure" research, that is, broad investigations "for learning's sake alone" such as large industrial firms report as paying handsome dividends. The Laboratory has carried on certain basic researches that pin-pointed no single immediate dollar goal but rather promised a number of practical rewards at some future date, usually not too long delayed. The benefits of this research have cropped up again and again in the seemingly quick solutions to specific practical problems in later years. Numerous examples can be cited which illustrate this point: The development of improved woods, stabilized by bonding resins to the cellulose of the wood fiber walls, drew heavily on the information regarding the dynamics of wood swelling and shrinking derived in earlier basic studies; the development of a high-strength laminated paper plastic proceeded swiftly to a successful conclusion because basic work on the engineering of a sheet of paper and control of its properties had already been well advanced at the Laboratory; the development of accelerated kiln-drying schedules with a minimum degrade of the lumber being dried had roots in studies of wood-moisture relations that as originally conducted would have seemed to have little practical interest; the development of pentachlorophenol as a wood preservative stemmed directly from theoretical studies of the relationship between chemical structure of compounds and their toxicity to living organisms.

Improve forest protection

The need for protecting Wyoming's forest and watershed lands from fires is obvious. Federal owned forest lands in the State are protected. However, no organized form of protection has to date been provided for the State and privately owned forested lands and watersheds.

The Governor of Wyoming in 1946 requested that a study of this situation be conducted under the cooperative provisions of the Clarke-McNary Act. The report of this study, entitled "The Importance and Need of Forest Fire Control in Wyoming" was published by the Wyoming Board of Land Commissioners. It includes the factual information available.

It is now estimated that 1,557,300 acres of forest areas and non-forest watersheds, other than federally owned, are in need of organized protection. On the 478,000 acres of such lands listed and bearing commercial forests there is an estimated 856 million board feet of saw timber together with over 10 million cords of cordwood.

If the forest industry is to be built up and expanded it should utilize the forest on private as well as public ownerships. To include the resource on privately owned forest lands calls for a guaranty of protection of the resource from destruction. The No. 1 protection that must be assured is protection from fire.

There is but little need to emphasize the close tie-in between forest cover and a sufficient and dependable supply of water. Also well recognized is the close relationship of forest to recreational values and to wildlife. Such resources are well known to the people of Wyoming

and to the Nation. The fact that the value of these resources is continually threatened by forest fires is added reason for an organized program of forest-fire control.

Under the Clarke-McNary Act of 1924 (and previously under the Weeks law of 1911) 43 States, of the 45 in need of a forest protection program, are already controlling forest fires. Wyoming is one of the last States with extensive forest resources without organized protection of non-Federal areas. No figures are now available as to the number of fires which burn each year on these unprotected lands, or the value of the resource which is burned. On the protected federally owned lands in Wyoming the reported annual loss for a 7-year period was 8,825 acres burned over and an estimated value of $44,000 for timber alone. Under similar conditions protection organizations elsewhere have found that losses on unprotected areas are at least 10 times greater than those on protected areas. Under the Clarke-McNary pattern of cooperative forest-fire control now being followed in 43 States, the Federal Government reimburses the State up to one-half of its expenditures for fire control.

Increase establishment of windbreaks and reforestation

Encouraging people to plant windbreaks and reestablish forests is the purpose of the Clarke-McNary program conducted by the State and the Federal Government. Under this program trees are produced by the State and sold at nominal prices to the State's citizens, with the Federal Government helping to bear a part of the cost. Wyoming was among the first of the States to embrace this program, starting it in 1926. The State agency doing this work is the agricultural experiment station at the University of Wyoming. The planting stock is distributed to Wyoming farmers (and more recently to forest landowners as well) at nominal prices. The persons doing the planting have paid a part of these trees' cost and the State and Federal Governments have shared the remainder of the cost. The State has not used the full Federal sum available to it in years past, conducting a smaller, although gradually expanding, program as a result. In 1950 it distributed 204,000 trees in this way; in 1940 it distributed 126,000; and in 1930 distributed 86,000.

Improve woodland management

The farmer-owners of some 250,000 acres of commercial woodland and other private owners with 156,000 acres have a resource that will yield cash returns if wisely managed. Good management involves protection from fires, planting, cut-over or poorly stocked land, and careful harvesting of the woodland products. Often the lumber, posts, and timbers cut for use on the farm or ranch are of considerable importance and add to the operating profits. Profitable markets can be developed for home-grown forest products. By handling the timber as a crop for continuous yields the owner of these small private woodlands will be able to get maximum production from his forest property. The technical assistance necessary to attain this end could be provided by especially trained farm foresters.

Obtain more reliable estimates of timber resources

Estimates of forest area timber volume growth and sustained yield made in this report are in some instances open to question. They are

the best that is available, but before careful plans can be prepared for making the most of Wyoming's timber resources more dependable resource information is needed.

The National Survey of Forest Resources, the purpose of which is to obtain an accurate estimate of the Nation's timber resource, has not begun work in the interior West which includes Wyoming. To get work under way there it would be necessary to enlarge the current program and assign a group of men for this purpose somewhere in the Rocky Mountain region.

In a relatively short time such a survey group would be in a position to furnish facts on—

1. Kind, volume, and location of timber stands;
2. Productivity, ownership, condition, and extent of forest land;
3. Rates of timber growth and depletion;
4. Present and prospective demand for timber products; and
5. Other information essential to adequate appraisal of the timber supply.

In addition to furnishing timber statistics and type maps, this Forest Survey unit would analyze basic factual information locally, regionally, and nationally in the light of current and foreseeable economic conditions, and thus assist in the development of a basis for forest policy determination.

RESEARCH PRESENTLY SCHEDULED FOR WYOMING WOODS AT FOREST PRODUCTS LABORATORY

Specific gravity tests

One of the first steps in evaluating the wood of a species is a specific gravity survey to determine the average weight of wood, both on a green and dry basis, per unit volume, and to determine the variation that may exist in a given species. Specific gravity is a measure of the actual wood substance in a piece of wood and the specific gravity value can be used to estimate such mechanical properties as hardness, bending strength, compressibility, and the like. Where relationships of specific gravity to strength have already been established for a species, a specific gravity survey of material from a particular forest site often will satisfactorily take the place of more expensive and time-consuming strength tests. A specific gravity survey of species from representative sites in Wyoming will thus indicate the relative value of wood grown there, and that from other sources.

In addition to indications of strength and other mechanical properties, the specific gravity of a species is also an indication of yield of pulp to be expected from a cord of wood. It is common practice to sell pulpwood by the stacked cord and to manufacture it into pulp that is sold by the ton. Wood of high specific gravity, therefore, will give greater tonnage yields on a cord basis than a wood of low specific gravity. This is an advantage to pulp manufacturers, and, therefore, pulpwood buyers seek wood of high density, particularly when they can secure it at no higher cost per cord than for wood of low density.

The most abundant species in Wyoming are lodgepole pine, Douglas fir, Engelmann spruce, and alpine fir. It is proposed to make a specific gravity survey of one or more of these species growing in Wyoming, the selection of the species to be by the regional forest officers. The material selected should include representation of about

100 trees divided among typical sites; that is, soils of different site quality as determined by soil factors, elevation, and rainfall. This might be expressed as good, medium, and poor, with respect to the relative height growth of trees of 50 or 100 years. Samples from about 25 trees usually are sufficient for a good evaluation of a given forest area. Where the trees are not of even age, or where they represent considerable variation in size, samples need to include representations of all merchantable material.

Considering the species mentioned, it is likely that a representation of 100 trees per species, divided among the most prevalent sites, would give a very good index of the Wyoming timber with respect to its mechanical properties and general usefulness in lumber form, as well as comparative yields of pulp and on a cord basis.

Pulping tests

As an aid to the increased utilization of western wood for pulp, paper, and allied products, it is proposed to make pulping tests on selected Wyoming species. The actual selection of the species, and whether live, beetle-killed, or material from thinnings or potential commercial pulpmill sites, will be left to the regional forest officers assigned to procure the material. Since data are lacking on the sulfate pulping of Rocky Mountain Douglas fir, it is recommended that consideration be given material from this species grown on Wyoming sites.

RESEARCH PRESENTLY SCHEDULED FOR WYOMING BY THE FOREST SERVICE'S FOREST AND RANGE EXPERIMENT STATIONS

Preliminary steps are being taken west of the Continental Divide in Wyoming to determine the cutting procedures best adapted to lodgepole pine. Earlier cutting methods are to be studied and analyzed carefully for what light they might shed on this problem. From such studies it is believed that the variations in forest and soil conditions can be identified and more effective procedures developed to meet special conditions. There are, for example, areas where the renewal of the forest has proceeded with only partial success and there are instances where—under the same treatment—the forest has regenerated abundantly. There are also instances where the residual forests have responded to the first cutting and have grown rapidly; and there are other instances—apparently under similar conditions—where little if any growth has occurred. The explanation to these and other contradictions resulting from present and past cutting practices will permit the preparation of sounder cutting methods for the future.

This work is to be supervised by the Forest Service's forest and range experiment station that serves Wyoming. It represents, of course, only a starting point in the solution of the forest management problems of Wyoming.

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